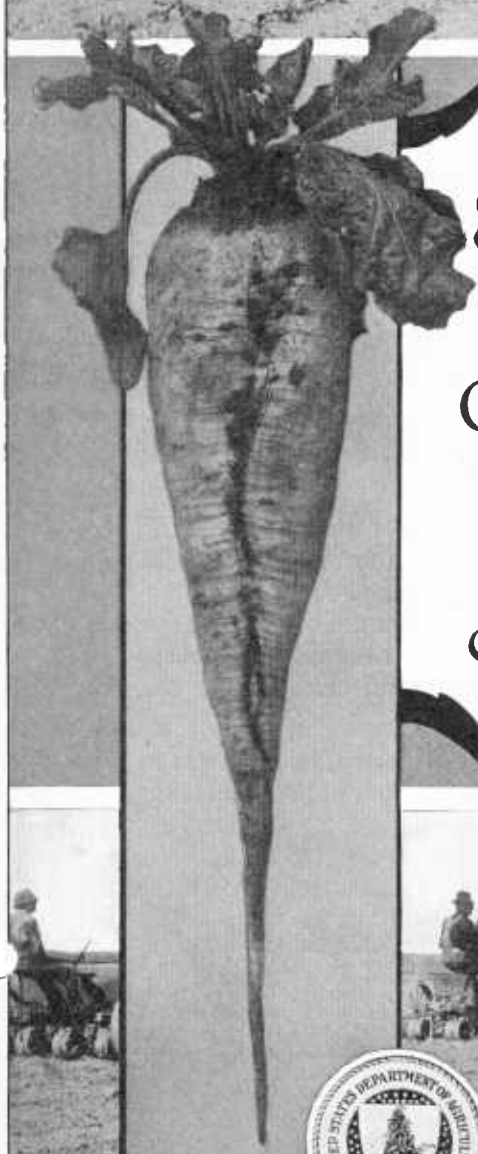
FARMERS' BULLETIN 568
UNITED STATES DEPARTMENT OF AGRICULTURE



SUGAR BEET GROWING UNDER HUMID CONDITIONS

SUGAR BEETS are grown commercially in 17 States. In 8 of these States the growers depend upon rainfall for their moisture in producing beets as well as other farm crops. In addition to the rainfall, the successful production of sugar beets depends upon either natural or artificial drainage of the soil, a proper system of crop rotation, the utilization of stable manure and other fertilizers, thorough preparation of the seed bed, careful blocking and thinning of the beets, and timely and thorough cultivation of the crop.

A supply of live stock which will balance with the crop production of the farm and insure the utilization of beet tops, pulp, and waste molasses as a source of stable manure is an important factor on the sugar-beet farm.

The land selected for sugar beets should be thoroughly drained, amply supplied with humus, and in good tilth. Humus may be supplied to the soil by plowing under green crops or by the application of stable manure.

The labor problems in sugar-beet areas are being solved by the development and manufacture of hill dropping devices for planting the seed, beet toppers, beet-harvesting implements, and unloading devices, and by so adjusting the beet planting and crop rotation that the labor is distributed throughout the season.

This bulletin should interest sugar-beet growers in the Northern and Central States who depend directly upon rainfall for soil moisture.

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

Washington, D. C. Issued February, 1914; revised August, 1920

SUGAR-BEET GROWING UNDER HUMID CONDITIONS.[1]

C. O. TOWNSEND,
Pathologist in Charge of Sugar-Plant Investigations.

CONTENTS.

SOIL.

SANDY LOAMS and clay loams are generally regarded as the best soils for the production of sugar beets, but any good soil if properly drained, fertilized, and otherwise fitted as a seed and root bed will produce satisfactory sugar beets provided the climatic conditions are favorable. (Fig. 1.) In general, more depends upon the physical condition of the soil and the way in which it is worked than upon its strict classification. The physical condition of the soil depends upon a number of factors which are of prime importance in the selection and preparation of the ground for sugar-beet growing. For example, the soil should be well drained and at the same time it should be capable of holding a sufficient amount of moisture for the needs of the beets. Even the so-called muck soils will produce good beets if they are well drained and properly worked. On the other hand, the loamy soils will sometimes produce very poor crops if not well drained or if otherwise improperly handled by working when too wet or too dry.

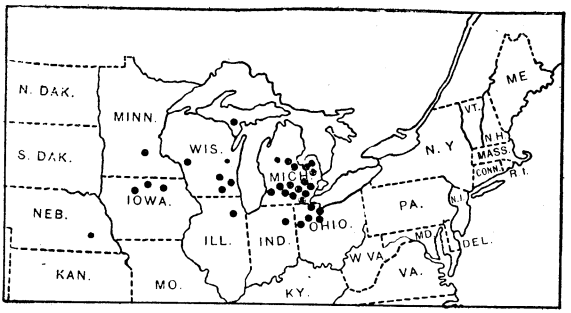


FIG. 1.—Map of zone of the Northern and Central States, showing the location of beet-sugar mills where beets are grown under humid conditions. There are some sugar-beet areas farther west where little or no irrigation is required for sugar-beet production.

[1] This bulletin is intended primarily for the farmer who is taking up sugar-beet culture for the first time, but it is hoped that the suggestions herein given will be helpful to the experienced grower whose results with sugar beets have not been entirely satisfactory.

For the retention of sufficient moisture in the soil for crop production the supply of humus is an important factor. A soil that is well drained and at the same time properly supplied with humus not only will hold enough moisture for the needs of the plants but will permit the air to circulate through it and enable the soil organisms to thrive and multiply, thereby liberating an abundance of plant food.

Hardpan subsoils should be avoided, especially if they are so near the surface that they will interfere with the proper growth and development of the roots. Very porous or gravelly subsoils which permit rapid leaching will not give the best results with sugar beets or other crops, because the moisture passes down too rapidly and not enough is retained in the soil proper to supply the needs of the plants. At the same time, if there is an abundance of rain on such soils, so that the plants are seemingly well supplied with moisture, the soluble plant food, the only kind which is of any immediate use to the plant, will be washed out and to some extent lost. The disadvantages of a porous subsoil may be overcome in a measure by furnishing the surface soil with a good supply of humus and giving it such tilth that as much of the moisture as possible will be retained. In selecting soils for sugar beets, therefore, careful attention should be given both to the surface soil and to the subsoil. In general, if a soil has been producing good crops of corn, potatoes, etc., it will produce good beets provided it receives the proper preparation and cultivation. In selecting a field for sugar beets it is advisable, therefore, to note the kind of soil and its condition, especially with reference to drainage and humus, the kind and quality of the preceding crops, and the nature and location of the subsoil.

The field selected should be reasonably free from weeds, since extreme foulness of ground adds very materially to the cost of growing beets. The beet field must be kept free from weeds if one expects to obtain anything like satisfactory results. It is sometimes claimed that a beet crop is of great advantage in freeing a field from weeds. This is true if the ground is properly handled, but one should see to it that not too large a percentage of the profits of the crop is consumed in fighting weeds, a condition which may be avoided by careful attention to the preceding crops with respect to weed growth. This emphasizes the importance of personal knowledge of the individual field.

CLIMATIC CONDITIONS.

The principal climatic conditions bearing upon sugar-beet culture are temperature, precipitation, and winds. Other things being equal, an average temperature of about 70° F. during the growing season, which is usually from May to September, inclusive, will give the best results so far as the sugar content of the beets is concerned.

If the average temperature during the growing period is very much above this point, sugar does not seem to form readily or, if formed, is utilized in the further growth of the plant instead of being stored in the root; consequently the beets are of poor quality. On the other hand, if the temperature is too low the beets do not grow well and the tonnage is correspondingly low. In addition to the temperature of the growing season, the spring and fall temperatures have much to do with the success or failure of beet culture. Late spring freezes following a favorable period for planting and germination will frequently destroy the young plants and involve considerable extra expense and labor in replanting. A protracted cold spell after the seed is planted will retard germination and growth and often give the beets a setback, from which they frequently fail to recover fully. A well-drained soil, rich in humus, will tend to offset these adverse conditions.

Cool nights and moderately warm days in the latter part of summer and in the fall are most favorable for the storage of sugar in the beets. The great danger from extreme cold in the fall is that the beets may be frozen in the ground. This sometimes occurs and causes considerable loss to the grower and to the manufacturer. Every grower should aim to get his beets out of the ground and delivered to the sugar company or protected from the cold before freezing weather sets in. If the roots themselves freeze after they are harvested, no great amount of damage will result, provided they remain frozen until they are worked through the mill, but if they alternately freeze and thaw, they will soon blacken, decay, and become worthless for sugar-making purposes. Frozen beets should not be put into the factory sheds with the expectation of leaving them for any length of time, as they will certainly spoil. The only safe way is to get the beets out of the ground before they freeze and put sufficient covering over them so that they will not be frosted. In case the roots are frozen or even frosted they should be worked through the mill with the least possible delay.

The amount of rain or snow which falls in a given area is beyond control, but considerable can be done toward getting the full benefit of the precipitation, whether it comes in summer or in winter. If the ground is plowed deep in the fall and left rough, the snow will not blow off as readily as it will from ground not plowed, and as the snow melts it will sink into the plowed ground. A good supply of vegetable matter in the soil together with proper tillage will aid materially in holding the moisture, while proper drainage will carry off any excess of water which might be injurious to the plants.

In most of the humid regions where sugar beets are grown winds do little, if any, damage to the sugar-beet crop; but in some areas wind control is an important problem and, indeed, is sometimes the

limiting factor in sugar-beet growing. In some of these areas the rainfall would be sufficient to produce a good crop of beets were it not for the hot winds in spring and summer, which frequently increase the evaporation to an abnormal extent. Windbreaks, an abundant supply of humus, and good soil mulches on the surface of the fields will largely offset the bad effects of these winds. In addition to the influence that these winds have upon evaporation they frequently do considerable damage in blowing the seed out of the ground before it germinates and in cutting off the young plants soon after they come up. To prevent this as far as possible, the surface of the fields in these areas should not be too smooth but should be kept slightly ridged and somewhat lumpy.

FIG. 2.—A manure spreader saves labor and spreads the manure more evenly than is usually done by hand.

FERTILIZERS.

The importance and the possibility not only of maintaining but of improving the fertility of soils are now recognized. There are three classes of fertilizers that are useful in maintaining and improving soil fertility, namely, stable manure, green crops plowed under, and the so-called commercial or mineral fertilizers. In the long run, no one of the soil improvers can be used to the exclusion of the others if one hopes to increase the fertility of his soils to the fullest extent and to reap the greatest profit from his labor. Stable manure is indispensable (fig. 2), but there are few farms on which enough manure is produced to maintain the soil in the best physical condition and to replace the fertilizing elements removed by the crops. For this reason in part, every rotation system should include one crop to be plowed under. Whether the primary object of the green

crop plowed under should be to increase the vegetable matter in the soil or in addition to this to increase the nitrogen content of the soil will depend upon the needs of each particular field, and selection of the crop should be made accordingly.

If vegetable matter alone is required, such plants as rape and rye may be used, but if nitrogen also is needed, then plants like peas, beans, clover, alfalfa, and sweet clover should be grown and plowed under. Vegetable matter in the soil is so essential and is so liable to be deficient that the importance of constantly renewing it can not be too strongly emphasized. The presence of vegetable matter improves the physical condition of the soil, helps it to retain moisture, and enables the soil organisms to increase rapidly and to do their work in soil improvement. A soil deficient in vegetable matter is said to be dead, which is literally true, since the beneficial soil organisms can not thrive in a soil devoid of vegetable matter. Our aim therefore should be to keep the soil alive and well supplied with air, moisture, and available plant food. We can not increase the actual amount of phosphoric acid and potash in the soil by the use of green manures or by crop rotations, but we can by these means do much to render these elements available for the growing plants.

When we have done all that we can to increase the available plant food by the use of green crops and stable manure and find that our soils are still too low in one or more of the elements necessary for the best plant growth, we should use commercial fertilizers. These should always be used intelligently; otherwise, loss instead of gain is likely to result. For example, if we plan to use a form of fertilizer that is not readily soluble we should apply it long enough in advance of the crop to give it time to become soluble, remembering that no mineral matter in the soil can be taken up and used by the plant until it is dissolved. On the other hand, if the fertilizer to be used is readily soluble, it should not be spread until the plants are ready to utilize it.

PLOWING.

Two important points in plowing for sugar beets should be kept in mind, namely, the time and the depth. Experience has demonstrated that the best results are generally obtained by plowing for beets in the fall. (Fig. 3.) Taking advantage of this fact, the beet grower will try to arrange his work and his crop rotation so that he can plow his beet ground in the fall, provided the soil and weather conditions will permit.

The advantages of fall plowing are numerous and distinct. In the first place, if the ground is plowed in the fall under proper moisture conditions it will be in better physical condition in the spring because of the fact that the weather has had free access to the soil par-

ticles and has put them in better shape to part with the plant food necessary for plant growth. The vegetable matter, either in the form of stable manure or as a green crop, should be plowed under in the fall. Fall-plowed land also more readily takes up the winter rains and snows. The winter precipitation if properly conserved, not only helps to put the ground in better condition for a crop, but it may be made to supply a large amount of moisture to tide over dry periods that are almost sure to come every spring or summer. If the ground is plowed in the fall, that much work is out of the way and the rush of work that is always present in the spring is greatly relieved. Fall plowing also enables the farmer to work down his ground earlier in the spring, thereby holding more moisture for the growth of the

FIG. 3.—Beet ground should be plowed in the fall whenever practicable, and a heavy green crop or a good coat of manure should be turned under at that time.

crop. It frequently permits earlier planting if the temperature conditions are right, thus providing a longer season for the crop to grow.

There are, of course, conditions under which fall plowing is impracticable, either because of lack of time or because of the too wet or too dry condition of the ground. Every farmer of experience knows the injurious effects of plowing ground when it is not in the right condition to be worked. If for any reason spring plowing becomes necessary it is even more important that the ground be in proper condition as regards moisture when plowed, in order to make satisfactory seed and root beds.

The depth of plowing depends upon the season when the work is done, and upon the nature of the soil and the subsoil. It has been demonstrated again and again that deep plowing, especially

of the heavier soils, if done in the fall, will give the best results for sugar beets, other things being equal. If the soil is deep and well supplied with humus and is plowed in the fall it is hardly possible to plow too deep, provided the ground is in condition to be plowed at all. If the soil is shallow and underlain with clay it will be better to plow only 1 or 2 inches deeper than usual, and then use the subsoil plow. If the plowing must be delayed until spring it is not advisable to plow more than 1 or 2 inches deeper than the ground was previously plowed, regardless of the nature of the soil or subsoil, since too much raw soil on the surface, especially at that season, does not make a good seed bed. It is assumed that the plowing is done with a moldboard plow, which is the implement com-

FIG. 4.—The spring-tooth harrow is a useful implement in preparing the seed bed.

monly used in humid regions. If, however, the plowing is done with a disk plow the ground can be stirred to a greater depth even in the spring without injury to the seed bed. This is due to the fact that the disk plow has a greater tendency to mix the top and bottom soils without bringing so much raw soil to the surface as is done with the moldboard plow.

The practice of subsoil plowing for beets is not so common as formerly. Experiments and field tests conducted by the writer indicate that the extra expense of subsoiling is not generally justified. There are instances, however, as indicated above, in which this operation should not be omitted. In general, if the plowing for any reason can not be over 7 or 8 inches deep and the subsoil is so hard that the beet roots can penetrate it only with difficulty, the action of the subsoil plow will be beneficial and it should be used.

The whole object of plowing should be to make a deep, rich seed and root bed which can be penetrated easily by the beet roots and from which the plants can draw an abundant supply of food necessary for their constant and rapid growth. The seed bed must be firm enough to hold the plants securely in place and to retain a good supply of moisture, but not so compact that the air can not circulate freely through it. The depth of plowing should be as nearly uniform as possible throughout the field, and the plow should be set so that the entire surface of the field is turned.

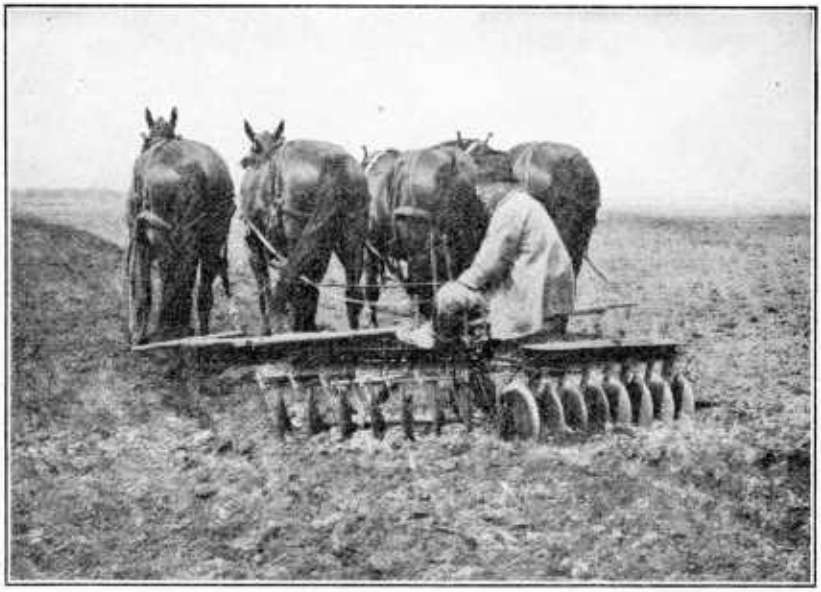


FIG. 5.—It pays to disk the ground before plowing. Disking is the first operation in the spring in making a seed bed out of fall-plowed land.

FITTING SEED AND ROOT BEDS.

Plowing is only one of the important steps in the preparation of the seed and root beds for beets, and unless the subsequent fitting of the ground is done with care it matters little whether the plowing is deep or shallow. In fact, unless the grower is prepared to work the soil down into a firm seed bed, it is better in most cases to plow shallow. It is assumed, however, that the grower wants the best possible seed bed for his beets. If so, he will plow the ground to a good depth in the fall and begin at once the preparation of the seed bed.

If the seed bed is carefully selected, properly supplied with humus, and thoroughly prepared, the success of the crop is more than half assured. As already indicated, the seed bed is not only the storehouse which is to supply the plants with food material and

moisture, but it must be a medium for holding the plants firmly in place during the growing season. The root must be constantly in contact with the fine moist particles of soil; otherwise it can not dissolve and take up the mineral elements necessary for the growth of the plant. The root needs also a certain amount of air, and the soil should therefore be in such physical condition that the air can circulate freely through it. At the same time no air spaces of any appreciable size should be allowed to remain in or below the seed bed. Air spaces will not form if the ground is in the condition known as friable, that is, readily falling apart when plowed. Air spaces are

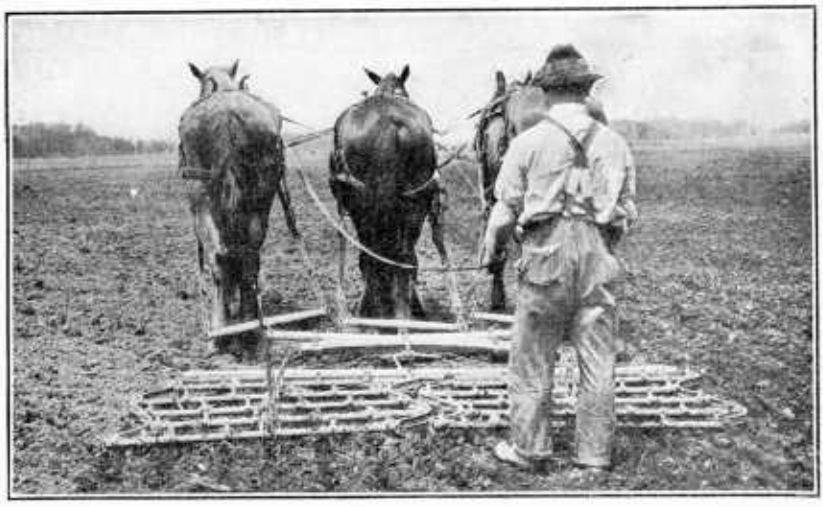


FIG. 6.—The spike-tooth harrow levels, smooths, fines, and firms the seed bed.

detrimental to plant growth in that they allow the seed bed to dry out too rapidly and do not permit a sufficiently firm and uniform medium for the proper growth of the plants.

The primary aim, therefore, in fitting the seed and root beds for beets should be to make them deep, fine, and firm. If the ground was thoroughly worked for the preceding crops and is in proper condition when plowed, the subsequent fitting of the seed bed will be much easier and less expensive. If the ground is plowed in the fall, the winter rains and snows will tend to make the root bed sufficiently compact. If the plowing is done in the spring or if the nature of the soil is such that it will not be sufficiently firmed by the natural elements, the plowing should be followed by a subsurface packer. It is not sufficient to pack the surface of the ground only, as is so frequently done, but the lower part of the seed bed which is, strictly speaking, the root bed, must be thoroughly firmed also. In the spring, as soon as the ground can be worked, it should be harrowed or disked. (Figs. 4 and 5.) Fall plowing will permit an

earlier preparation of the seed bed in the spring, thereby lengthening the growing season. If the field is free from weeds a good harrowing to hold the moisture will be sufficient, but if weeds are starting, it will be best to double disk just deeply enough to destroy the weeds and then harrow. (Fig. 6.) The roller (fig. 7) is a useful tool in firming the surface of the seed bed, and the alternate rolling and harrowing of the field will usually put it in good condition for planting, provided the lower part of the seed bed and the root bed have been well firmed by either natural or artificial means.

The ground should never be worked when it is too wet, as that invariably injures the texture of the soil, prevents the free circulation of the air, and renders the formation of a first-class seed bed im-

FIG. 7.—The roller crushes the clods and firms and smooths the seed bed. It is also useful in pressing the plants firmly in the ground after thinning and in breaking the crust that sometimes forms over the seed or around the plants.

possible. The object sought, namely, the making of a deep, firm, well-drained, well-aerated, moisture-holding seed bed, should be kept in mind, and the methods employed and the tools used in securing the desired results must be governed to some extent by the condition of the individual field.

DRAINAGE.

The proper disposal of excess moisture from agricultural lands is one of the important factors in beet growing as well as in the production of other crops. Drainage is of two kinds, natural and artificial. Natural drainage may be due to the porosity of the soil, which allows the water to pass through it readily, or it may be due to the slope of the surface soil or the slope of the subsoil. Naturally drained soils may or may not be good crop producers. If the water passes through or off from the soil too rapidly the soil moisture remaining may not

be sufficient for crop production and the fertility is liable to be leached out or washed away to such an extent that the soil is deficient in plant food.

Soils may be drained artificially by means of the open ditch or the blind ditch. In most beet-growing sections the land is too valuable to admit of the use of the open ditch to any considerable extent, except under some conditions as outlets for the blind ditches. Furthermore, open ditches are often troublesome in performing field labor and render it more expensive because of the shorter "bouts" and more frequent turning. For this reason the blind ditch in which tiles are commonly used is the method generally employed in artificially draining beet land. No invariable rule can be given for the depth at which tiles should be laid, but in general they should be deep enough so that they will not be disturbed by deep plowing and at the same time near enough to the surface so that the excess water will readily find its way into them. The depth of the tile must, therefore, be governed in part by the desired depth of plowing, but more particularly by the nature of the soil and of the subsoil. The hard subsoil which holds the water and causes undrained soil to become water-logged must be deep enough to allow the tile to be laid at the proper depth, otherwise it is doubtful whether the surface soil is deep enough to form a good root bed for sugar beets. (Fig. 8.) The tile when laid in the ditch should form a continuous but very gentle slope toward the outlet, and should be large enough to carry the excess water off readily.

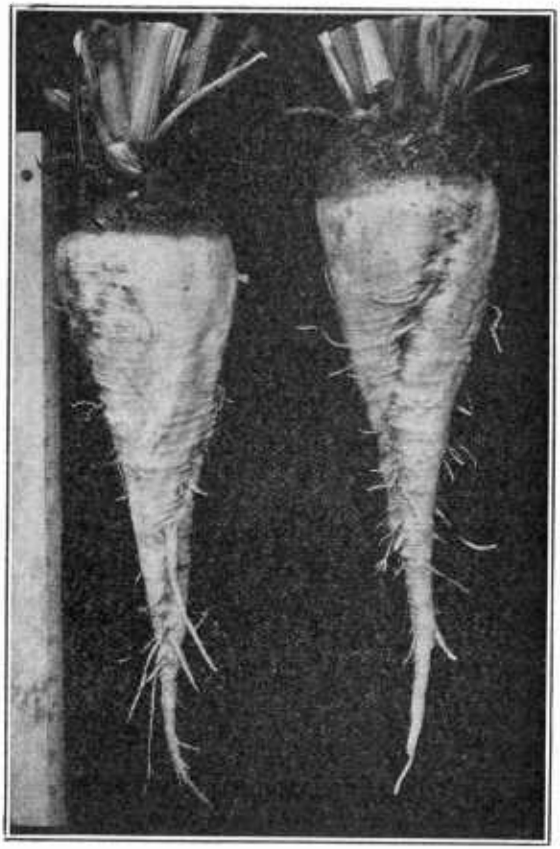


FIG. 8.—Sugar-beet roots when uninjured by insects or disease or distorted by a hardpan subsoil or high water table are long and tapering.

The rows of tile should be sufficiently close to drain the entire water-logged area. While sugar beets are hardy and thrive under many adverse conditions, no crop responds more readily to good drainage, and therefore the initial cost of artificial drainage for sugar beets is a paying proposition which leaves the land in better physical condition for the other crops.

Figure 9 shows the effect of water-logged land on beets. Such roots as those shown in this illustration are not adapted to milling, and in large quantity they would be liable to rejection by the sugar company because of poor quality.

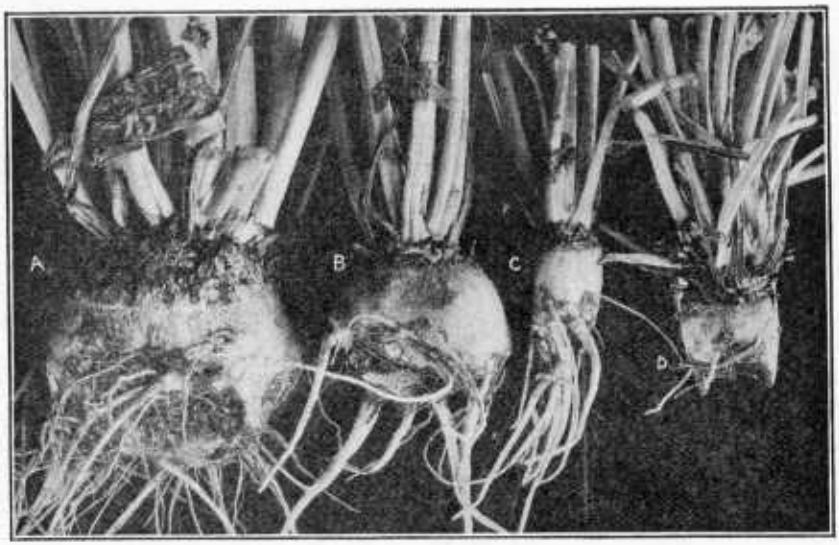


FIG. 9.—Sugar beets showing the effect of a high water table, due in this case to poor drainage. Not all poorly formed beet roots are due to poor drainage.

HOLDING THE MOISTURE.

The ability of the soil to hold the required amount of moisture for plant growth is of an importance equal to good drainage. It should be remembered that soil moisture exists in part as free water that will readily flow off or through the ground under proper conditions and in part as moisture which adheres to the soil particles and keeps them damp. A soil which allows practically all the moisture to pass through it or to evaporate and leaves it comparatively dry in a short time is in poor condition for crop production. This unfavorable condition may be overcome to a considerable extent by supplying the soil with humus and by such tillage as will keep the ground from cracking and keep the surface of the soil covered with a mulch.

If the suggestion given in regard to preparing the seed and root beds are followed and the soil is left firm and compact, it will hold

moisture to a far greater extent than if left loose and porous. At the same time the surface must be kept loose enough to prevent it from crusting or baking, as this condition favors rapid evaporation. A good supply of humus in the soil, together with enough lime to keep the soil sweet, aids very materially in keeping it friable, so that it will not so readily crust or crack, thereby indirectly conserving the soil moisture.

PLANTING.

WIDTH OF ROW.

For a number of years there has been considerable difference of opinion among beet growers in regard to the most profitable distance between the beet rows. The fertility of the soil and its water-holding ability are important factors in deciding this question. In some field tests conducted for a number of years at different places in which the distances 20, 24, and 28 inches were used, it was found that the most profitable distance between rows, everything considered, generally was 20 inches. It is true that the narrow rows require more work because of the larger number of rows per acre and the greater care necessary in cultivation, but in most cases the extra expense was more than offset by the heavier yield, even though the individual roots were sometimes smaller. In a few experiments 18 and 22 inches were tried, but the results did not differ materially from those obtained in the 20-inch rows. Considering the yield and quality of the beets as compared with the cost of growing them with different widths of row, 20 inches is generally satisfactory. One argument in favor of the wider row is that the grower in using the wide row is able to utilize a corn cultivator and thereby avoid the expense of an extra tool for cultivating his beets. However, good, strong land that is capable of growing a satisfactory row of beets every 20 inches will soon pay for a beet cultivator in the extra yield, and if one expects to remain in the beet-growing business it will certainly pay to have such a cultivator, even if the acreage each year is small.

DEPTH OF PLANTING.

The depth at which beet seed is planted is one of the most important factors in securing a good stand of beets, and a good stand is of prime importance in producing a good crop. The more quickly the leaves of the young plants get through to the light and the roots strike down into the firm root bed the better the stand and the stronger the plants will be. Therefore shallow planting, one-half to three-fourths of an inch, is advisable provided there is moisture enough in the soil to produce germination. The seed should be placed in the moist soil at such a depth that the moisture can be kept in contact with the seed until the roots have begun to develop.

Because of varied composition and the texture of different soils there is considerable variation in their ability to hold the moisture near the surface. Climatic conditions also have a marked influence on soils in this regard. In general, the depth of planting will vary from one-half inch to 1½ inches. Good stands are seldom obtained with deeper planting. In the case of deep planting a slight crusting of the ground or a reduction of the temperature of the soil may retard the germination and growth of the seedlings, causing them either to fail to get through to the light or to get through in a weakened condition. It is therefore much safer to plant shallow and then use every effort to keep the moisture near enough to the surface to produce a quick and even germination.

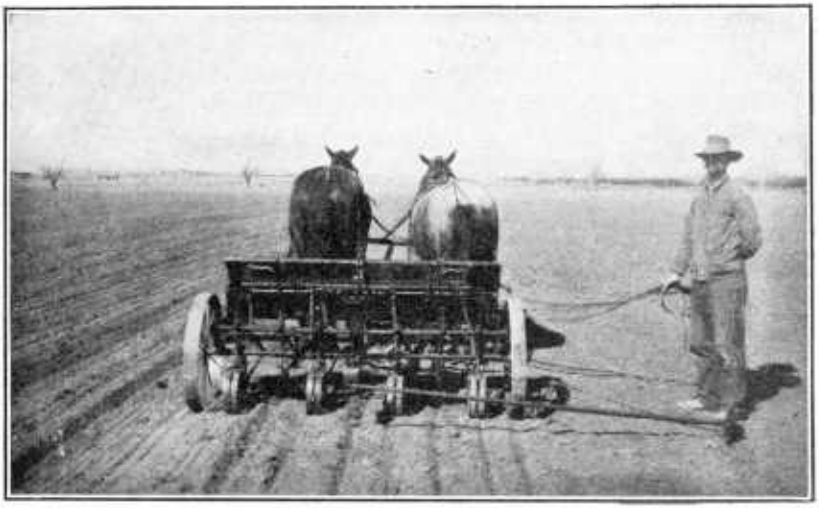


FIG. 10.—The seed bed should be firm and smooth, and the press wheel should exert a constant and uniform pressure over the rows of planted seed.

The press wheels on the drill (fig. 10) are important agencies in holding or bringing the moisture up to the seed and should be set so that they will exert a firm and uniform pressure on the drill row. In case this pressure is not sufficient to produce the desired result, the smooth roller is a very satisfactory tool to supplement the work of the press wheels. It is assumed, of course, that the ground is in just the right condition when the planting is done; that is, that the soil is not damp enough to stick to the press wheels. The same precaution is necessary when the roller is used, so that the ground in both cases will be left firm but mellow.

It is important also that the depth of planting be uniform. This applies to one drill shoe as compared with another and also to the same drill shoe in different parts of the same field. The depth at which one drill shoe plants as compared with another is a simple

matter of adjustment, which can best be made on a level, smooth surface before the drill is taken to the field. The problem of making the same shoe plant at the same depth throughout the entire length of the row each time across the field is a question of uniformity in the firmness of the seed bed and the freedom of all parts of the field from elevations or depressions. If there are soft areas, so that the drill wheels sink in to a greater depth in some places than in others, the seed will be deposited at correspondingly varying depths. Likewise, if there are small depressions or elevations over which the wheels or drill shoes pass, the seed will be planted deeper or more shallow, as the case may be.

The result of uneven depth of planting is a lack of uniformity in the size of the young beets, a condition which is troublesome in

FIG. 11.—Sugar beets are blocked into tufts by means of a hand hoe operated directly across the row, as shown in the cut. The thinning must be done with the fingers in order to leave just one plant in each place. The care with which these operations are performed has an important bearing upon the yield and quality of the crop produced.

thinning. Either the larger beets must be thinned when the smaller ones are too small or the larger ones must be allowed to get too large.

SPACING AND THINNING.

At present nearly all beet seed is planted in solid rows, although hill planting is receiving considerable attention. Under present conditions the beets must be spaced and thinned, since they must stand one in a place at suitable distances apart in order to produce satisfactory yields. Spacing is nearly always done by means of a hand hoe of convenient size, which is operated at right angles to the row (fig. 11), leaving the remaining beets in small tufts at suitable dis-

tances from each other in the row. The beets that are removed by the hoe must be cut off at such a depth that they will not grow again. Numerous attempts have been made to devise a power implement that will space several rows at one time. The mechanical construction of such an implement is comparatively simple, but the fact that the beets in the row are seldom uniform in size or in stand makes the use of such a tool unsatisfactory. In the case of hill planting, if the seed is planted in definite hills and not scattered, the spacing is done when the seed is planted, thereby saving seed and the labor of blocking.

It is always desirable to leave the larger and stronger plants to make the crop, and these are seldom to be found at regular and desired intervals in the solid row. Hence, judgment must be used in spacing the beets. Sometimes the spacing must be a little wider and sometimes a little closer to meet these requirements, and there is no implement equal to the hoe in the hands of an interested, intelligent, and observing grower. After the spacing has been done the remaining beets should stand in tufts or bunches at intervals of 8 to 12 inches in the row. If the soil is strong and has a good water-holding capacity it is safe to leave the tufts a little closer than if the soil is not so strong and has less ability to hold moisture. Spacing the beets is therefore a matter of sound judgment based upon experience and a knowledge of the soil conditions.

Owing to the nature of the seed balls, composed of from one to seven seeds, the seedlings generally stand very close together in the tufts. This necessitates thinning by hand, which is the most tedious operation in beet growing. The thinning must be carefully done, so that the beets will stand one in a place at intervals governed by the distance between the tufts when the beets were spaced. It is a well-known fact that two beets growing in contact with one another will seldom give as great a weight of root as a single beet would have produced in the same place. This emphasizes the importance of thinning to a single beet in each place. The success of the crop depends also to a great extent upon the time at which the thinning is done, as well as upon the care that is exercised in doing it.

Thinning should be done just as soon as possible after the beets get large enough to be handled, which is usually when they have four leaves. The reason for early thinning becomes apparent when one remembers that there is in the soil at a given time a certain amount of available plant food and moisture, and the earlier the useless plants are removed the more food and moisture will be left for the beets that are to make the crop. The same principle holds good in regard to weeds, which should all be carefully removed from the row when thinning. As in spacing, the tufts containing the largest and strongest beets should be left, so in thinning, the largest and

strongest beet in each tuft should be left to make the crop. Unless this is carefully watched the largest beets will invariably be pulled out, as they are always the easiest to get hold of. Looking after these minor points will make a remarkable difference in the final yield.

After the beets are thinned they frequently wilt for a time, leaving the tender drooping stems exposed to the hot rays of the sun. For this reason the earth should be drawn up around the plants when thinning, in order to protect them as far as possible.

HOEING.

The beets should receive a good hoeing at the time they are thinned; that is, the earth should be loosened upon all sides of the beet and the weeds carefully removed. The number of subsequent

FIG. 12.—The hand hoe is used in keeping the weeds out of the beet fields and in forming a mulch around the beets.

hoeings will depend upon local conditions. As a matter of fact the subsequent hoeings are not hoeings at all, as the work is usually performed, but consist simply in cutting out the weeds. This work is good as far as it goes, but the soil should be stirred around each beet and the hoeings should be repeated often enough to keep the soil loose as well as free from weeds. (Fig. 12.) In going over the field for the first hoeing after the beets have been thinned, a close watch should be kept for doubles, and wherever more than one beet in a place is found, all but the largest in each case should be pulled out.

CULTIVATING.

Sugar beets should be given their first cultivation just as soon as the rows can be followed. It is usually possible to cultivate once before the spacing and thinning is done. A second cultivation should

be given the beets as soon as they straighten up after thinning. No fixed rule can be laid down as to the number of cultivations that a field should receive during the season. This must be governed by soil and weather conditions and by the presence of weeds. In general, there should be a cultivation after each rain, and in case of drought the cultivations should be frequent enough to maintain a surface mulch, in order to retain the moisture below.

It should be kept in mind that cultivation serves three important purposes, namely, opening the soil to admit air, enabling it to absorb and retain moisture, and destroying weeds. These conditions produced by cultivation tend to liberate and conserve plant food for

FIG. 13.—A 4-row beet cultivator with weeder knives and deer-tongues usually used in the first cultivation before the beets are thinned.

the growth and development of the beets. Air is just as essential to the activities of root growth and development as moisture. If the ground is stirred, not only will the air circulate through it, but it will absorb rain more readily and the soil mulch formed by cultivation will tend to hold the moisture below. The mulch is more effective if it is granular or slightly lumpy in part rather than of dust formation.

Weeds rob the soil of both moisture and fertility and therefore should not be allowed to exist either in or between the beet rows. The attachments or combinations of attachments to be used on the cultivator will depend upon the object desired in cultivating; that is, whether it is to break up a crust, to form a mulch, to destroy

weeds, or to perform two or more of these operations at one cultivation.

The 4-row riding cultivator with foot guides (fig. 13) is generally used in most localities where sugar beets are grown. Few sugar-beet growers realize what large numbers of beets are destroyed annually in the process of cultivating the crop. It may be that only a few beets are destroyed at each cultivation, but the loss amounts to considerable in the course of the season. It is safe to say that not infrequently the expected profit on a field of beets is entirely lost through the poor operation of the cultivator. The loss from this source is more likely to occur if the rows are crooked, if the horses

FIG. 14.—The first operation in harvesting beets by hand consists in loosening or lifting them so they can be pulled.

used have not a steady gait, if the seed bed was not properly prepared, and if the driver is careless.

There is a wide difference of opinion in regard to the depth of cultivating, the distance that the cultivator teeth should run from the beets, and the kind of tools that should be used on the cultivator. These are all details that depend upon the condition of the soil, the size of the beets, and the object to be accomplished by cultivating. If the ground is quite foul, weeders should undoubtedly be used, but they should be followed by deer-tongues set so that they will cut a little deeper than the weeders, in order to make a good mulch and to prevent the formation of a crust just below the mulch. If the ground has a tendency to become hard, the disks followed by deer-

tongues properly adjusted will do good work while the beets are quite small. The disks should be set so that the dirt is thrown slightly away from the beets, and the deer-tongues should be set so that they will make a mulch over the entire surface of the ground between the beet rows and at the same time fill the small trench made by the disks. When the beets get larger, the deer-tongues or similar tools that will maintain a good mulch and keep the soil open so that a complete circulation of the air in the soil can be kept up will usually be sufficient.

In no case should the cultivator teeth be allowed to run deep enough or close enough to the beets to cut off the feeding roots, and

FIG. 15.—Front view of a motor-driven beet-harvesting machine which pulls, tops, and piles the beets in one operation. The lifting device is raised out of the ground, in order to show its construction. Directly above the lifting points is a toothed apron which holds the beet upright until topped by two rotating disks just back of of the apron (not shown in the cut).

care should be taken to avoid throwing dirt into the crowns of the beets.

As a rule the beet crop is laid by too early. It has been found by repeated experiments on a commercial scale that by continuing cultivation just as long as it is possible to get through the beets, even if some of the outer leaves are broken, the tonnage will be perceptibly and profitably increased without any decrease in the sugar content.

HARVESTING.

Harvesting sugar beets by hand consists of three distinct operations, i. e., lifting, pulling, and topping. The lifting is done either with a double-pointed implement somewhat resembling a 2-pointed

plow (fig. 14), or by means of a side lifter, which is a small shoe or plow on the end of a long shank. The former is so operated that one point of the implement passes along the row on either side of the beets, raising them several inches out of the ground. The latter passes along one side of the beet row and loosens the beets without appreciably lifting them out of the ground. These implements are usually operated by means of horse power, but tractors with proper attachments may be used. The kind of lifter is largely a matter of personal choice. As a rule, the side lifter has a lighter draft, but in either case the only precaution necessary is that all the beets be loosened and that as few of them as possible be broken.

After the beets are loosened they are thrown into piles. The number of rows of beets used on making a pile row is a matter of con-

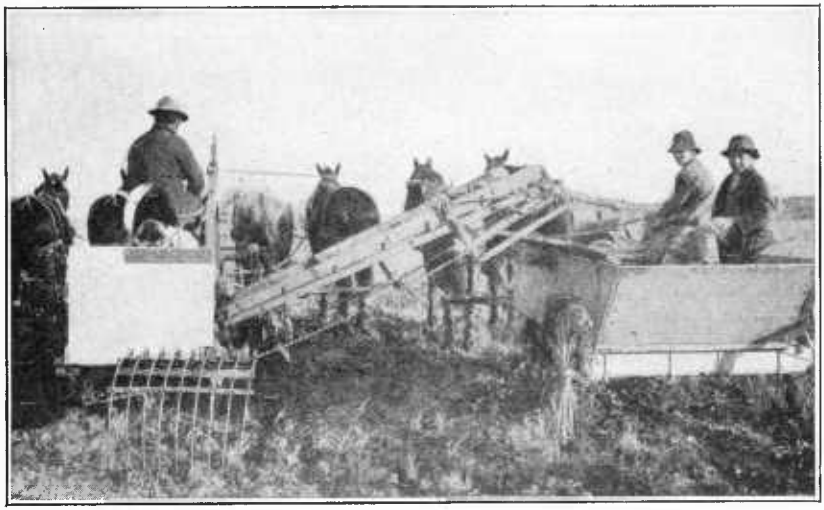


FIG. 16.—A horse-drawn beet-harvesting machine, showing the elevating device which loads the beet roots, ready for hauling to the mill or loading station. This device tops, pulls, and loads the beets in one operation.

venience. The larger the piles the more quickly the beets can be loaded. When the beets are pulled, more or less dirt will cling to them, but as much as possible of this should be removed by striking two or more of them together when pulled, taking care not to bruise the roots unnecessarily. Before topping the beets the ground where the topped beets are to be piled should be smoothed down and freed from clods, tops, etc., so that the beets can be forked onto the wagon free from all refuse. In topping the beets they should be cut off squarely at the lowest leaf scar. This is usually done with one stroke of a heavy knife.

Several types of mechanical sugar-beet harvesters which lift and top the beets at one operation (fig. 15) have been devised, and it is

probable that some of them will be in general use in the near future. These implements are either horse drawn or operated by a motor. In some instances two implements are required for the harvesting operation; one simply tops the beets and the other removes the roots from the ground. Some of the harvesters not only lift and top the beets, but in some instances the roots are piled ready to be loaded upon wagons or even conveyed to the wagon, as shown in figure 16. The mechanical harvester will reduce the amount of labor and expense in harvesting the sugar-beet crop and will enable the grower to handle his crop in a much shorter time than can be done by hand.

When the beets are delivered at the factory or loading station, samples are taken and if the beets have not been properly topped the sample is retopped. The percentage of weight removed by this extra topping is called the "crown" tare, and from the sample is de-

FIG. 17.—Field of beets ready to harvest. The field men are taking samples to be tested.

termined the tare for the entire load. The tare consists of two parts, i. e., the crown tare and the dirt tare. The latter is the percentage of dirt that clings to the sample as compared with the weight of the roots (fig. 17). In actual practice in determining the tare the sample is first weighed just as it comes from the load; it is then properly topped, the dirt is removed by means of a stiff brush, and the clean sample is again weighed. The difference determines the percentage of tare.

The beets should be covered as soon as possible after they are topped, in order to prevent evaporation. The roots work much better in the mill if they are kept fresh and crisp, and they lose considerable weight if exposed to the sun and wind. If the beets are to remain in the field only a short time after topping it is usually sufficient to cover them with the tops, but if they are to remain for

some days, and especially if there is danger of freezing, the piles of roots should be covered with a sufficient layer of earth to protect them.

CROP ROTATION.

The best results are obtained with all crops when a carefully planned system of crop rotation is practiced. We hear now and then of a successful one-crop farmer, but he is always the exception to the rule and it is only a question of time when some pest or some climatic condition will overtake him and show him the folly of such a course. Closely related to the one-crop farmer is the farmer who grows several crops but persists in making each crop follow itself for a long series of years. These methods are attended with a great deal of risk, not only on account of the poor physical condition of the soil which often results from this practice, and not so much because of the plant foods removed from the soil as from the propagation of pests of many kinds. These pests may be either insects, fungi, or bacteria.

As a rule, each particular pest develops best and increases most rapidly on some particular crop. It sometimes happens that one or more of these pests may thrive upon several crops. For example, the fungous disease known as scab attacks both the white potato and the sugar beet. The fungus causing this disease may live over the winter in the soil and attack the next crop. Hence potatoes following beets or beets following potatoes that were affected with scab may be seriously injured by this disease even though it is the first year that this particular crop is grown in that soil.

It is important that care should be exercised in planning a rotation system, in order that the possible evils may be avoided as far as practicable and the best results obtained. No hard-and-fast system of rotation can be advocated for any locality, but a carefully planned system should be worked out for each farm to meet its individual needs. There are some principles of general application, however, and these should be borne in mind in planning a rotation system in which sugar beets are included.

If practicable, the crop preceding the beets should be of such a nature that it can be harvested in time to plow the ground in the fall for the coming beet crop. The crops preceding and following the beet crop should be of such a kind that they will not serve as food or host plants for the same pests that attack beets. For example, beans preceding beets and small grains following them will meet these requirements fairly well and thereby form part of a good rotation system, provided it fits in with the other farming operations and with local conditions. There should be one leguminous crop, such as peas, beans, clover, or alfalfa, and if the soil is deficient in

humus a crop of some kind should be grown to plow under for green manure. This is especially important where the farm does not furnish sufficient stable manure to supply the soil with the requisite amount of humus. There is some danger in following a sod of any kind with beets, on account of the possible presence of insect pests, which often live over the winter in the sod and are ready to attack the beets the following year. Sod ground generally does not make a satisfactory seed bed for beets unless plowed in the fall. It is safer, and more satisfactory, therefore, to follow sod with some other crop before planting to beets.

LIVE STOCK.

One of the most profitable adjuncts of good beet farming is live stock, especially cattle and sheep. They will utilize the beet tops to the best possible advantage. It is well known that the leaves and

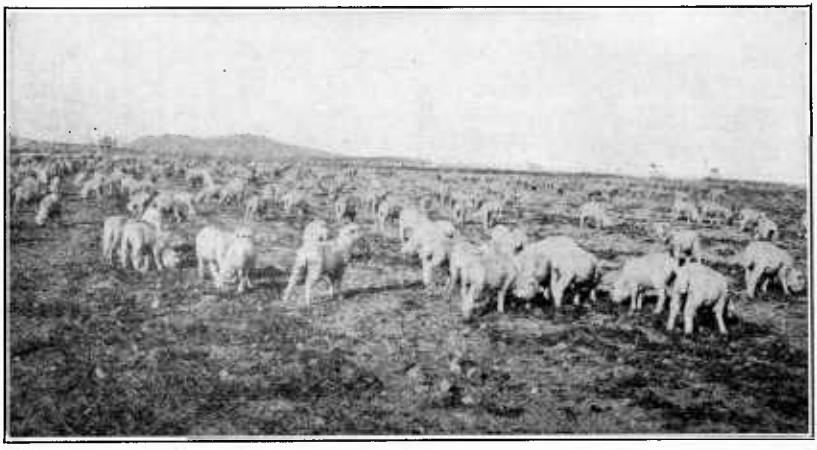


FIG. 18.—Sheep feeding on beet tops (leaves and crowns), a valuable by-product on every beet farm. The fresh beet tops are frequently equal in weight to the beet roots that are hauled to the sugar mill.

crowns of beets, the parts removed when the beets are topped, contain a large percentage of the mineral matter taken up in the process of growth and must therefore be fed sparingly at first. If the tops are properly fed to cows, the flow of milk will be increased, the cows put in good physical condition, and the mineral matter and a portion of the vegetable matter may and should be returned to the soil in the form of stable manure.

Beet tops are good for sheep also, but they should be fed sparingly at first and gradually increased as the animals become accustomed to the new feed. In feeding tops to either cattle or sheep it is customary in many localities where sugar beets are grown to pasture the tops (fig. 18) after the beets have been hauled to the factory. This practice eliminates the work of gathering and hauling the tops,

and leaves the droppings on the field to enrich the soil. This method of feeding the tops has one serious disadvantage in that the ground is often in the right condition at that season of the year to be unduly packed by the trampling of the stock. In the irrigated sugar-beet areas beet tops are used to a considerable extent for ensilage, but in the humid areas the tops are generally pastured or cured and fed like hay. The method of feeding the tops is a detail which may be worked out to best advantage for each farm, depending upon local conditions, and should not deter any farmer from keeping all the live stock that the size of his farm, his system of crop rotation, and the available help will permit.

BY-PRODUCTS.

BEET TOPS.

The by-products of the beet field and sugar mill that are of special importance to the farmer are the beet tops, pulp, molasses, and waste lime. The value of beet tops as a stock feed has been briefly mentioned under the subject of live stock. If properly handled they form a valuable asset for the beet grower, and in considering the value of a beet crop they should be reckoned at their real worth as a stock feed. Many farmers sell the tops for a cash price ranging from $2.50 to $5 per acre. In this case the beet grower is the loser, for two reasons: In the first place, the tops are of greater value to him as stock feed, and, in the second place, if he allows the tops to leave his farm he loses their manurial value, consisting of a large part of the mineral plant food taken up by beets in the process of growth, and also their humus value, which results from returning the top to the soil in the form of stable or barnyard manure.

The beet tops are often utilized by turning the live stock into the fields after the beet roots are removed, as pointed out under the heading "Live stock." A more economical way to handle the tops is to gather them into piles soon after they wilt and before they become thoroughly dried. In this condition they can be gathered with much less loss than would be the case if they were left scattered over the ground until dried. After they have cured in the piles they should be hauled to the feed yard, where they should be fed in properly constructed racks to avoid waste. (Fig. 19.) The resulting manure should be hauled to the field and evenly spread, preferably with a manure spreader (see fig. 2), and plowed under. If the tops were free from disease the manure can be profitably applied to the ground to be used for the next crop of beets. However, if any disease, especially leaf-spot or crown-rot, was noticeable on the beet leaves and crowns, the manure should be used only on ground that is not

to be put into beets for two years or more; or, better, the wilted tops should be put into the silo, where if the ensilage is properly cured all leaf-spot spores will be killed.

PULP.

Beet pulp is likewise an excellent stock feed. This by-product is the refuse that remains after the beet roots have been sliced and the sugar extracted. As a stock feed it may be used either as green pulp, that is, just as it comes from the mill, or it may be dried. The pulp is prepared for the drier by having the excess water pressed out, after which it is subjected either to direct heat or steam heat until it is approximately dry. It may be dried by itself or it may have molasses

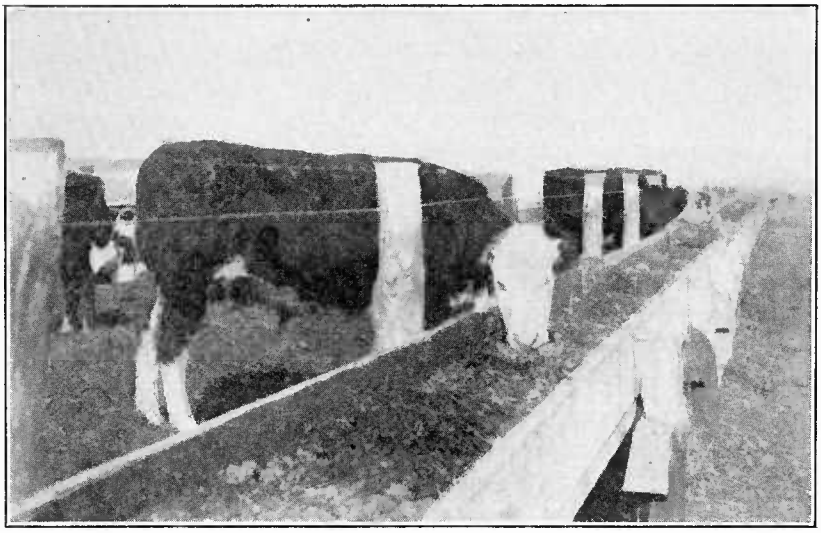


FIG. 19.—A more satisfactory method of feeding beet tops and similar feeds than that shown in figure 18, although this method involves the extra labor of gathering and hauling the tops and of distributing them in the trough at the regular feeding periods.

or other material mixed with it to improve its feeding value. The composition of the dried pulp as guaranteed by one of the large dealers is: Protein, not under 8 per cent; fat, not under one-half of 1 per cent; sugar and starch, not under 4 per cent; fiber, not over 20 per cent; extract (carbohydrates), not under 58 per cent; total carbohydrates, including fiber, not under 76 per cent; ashes, 2½ per cent.

While the pulp, either green or dried, is an excellent stock feed, it is not a balanced ration and should therefore be fed with other protein material. The dried pulp is sacked and may be shipped long distances, while the wet pulp is usually fed near the mill, although it is sometimes hauled back to the farm by the beet grower or trans-

ported a considerable distance by rail. In any case farmers, and especially dairymen, will find this by-product an excellent addition to other stock feed. The dried pulp will keep almost indefinitely if stored in a dry place, and the wet pulp will keep for several months even when piled on the ground in the open.

MOLASSES.

Molasses is an important by-product of the sugar mill not equipped with the Steffen process. Molasses contains nearly 50 per cent sugar, but owing to the large quantity of salts present the sugar will not crystallize out. Sugar-beet molasses was formerly used in large quantities for the manufacture of alcohol, but in recent years it is practically all used as a stock feed. It is usually fed by mixing with hay, beet-top ensilage, or pulp, but is sometimes dried with the pulp. Owing to the large amount of salts present molasses should not be fed in large quantities. Since its feeding value is due largely to the sugar present it should be fed with some protein feed, such as alfalfa or clover hay.

One of the salts present in considerable quantity in beet molasses is potash. Some sugar companies have recently installed potash plants, in which the potash is extracted from the molasses and used as a fertilizer.

WASTE LIME.

Waste lime is a by-product of the sugar mill which under certain conditions is of considerable value to the farmer in correcting the acid condition of the soil. It is well known that a soil should be neutral or slightly alkaline in order to produce the best results with most field crops. Lime has the ability to combine with the injurious acids that develop in the soil and thereby render them neutral. If, therefore, a soil is inclined to be acid, an application of lime will be beneficial. If just enough lime is added to combine with the acid in the soil the result will be a neutral soil; that is, one which is neither acid nor alkaline. If an excess of lime is added, the soil will be rendered alkaline. Lime has other beneficial effects upon the soil, such as the fixation of atmospheric nitrogen and the liberation of nitrogen from humus.

Since a slightly alkaline soil is not injurious to sugar beets or other field crops, it is advisable in case a soil has become acid to give it a good application of lime. Some crops, such as cowpeas and redtop, will thrive with less lime in the soil than some other crops, such as alfalfa and sugar beets. Ordinarily, an application of from 500 to 2,000 pounds of waste lime per acre will correct the acidity and otherwise improve the soil. In this connection it should be stated that poorly drained soils are the ones most inclined to become sour,

which still further emphasizes the importance of good drainage. It is not necessary that waste lime from the sugar mill be used to correct soil acidity. Any finely divided or air-slaked lime will serve the purpose. However, the waste lime may usually be had for the hauling and for that reason is an inexpensive remedy for sour soils.

The physical condition of certain soils may be improved by the use of lime. This is especially true of heavy soils, which tend to become too compact. An application of lime to such soils will often render them porous, thereby enabling the farmer to prepare more satisfactory seed and root beds for his crops. Furthermore, such soils will more readily absorb and retain moisture and allow the air to circulate more freely through them.

Lime is in itself an important plant food, and soils deficient in lime may easily be corrected by an application of the waste lime from a sugar mill. In addition to the lime itself, this by-product, known as waste lime, lime cake, or sludge, contains from 3 to 4 per cent of nitrogen, 4 to 5 per cent of phosphate, and 8 to 10 per cent of organic matter, all of which make it a valuable fertilizer for soils deficient in one or more of these substances. The value of this by-product has never been fully realized, and it should come into more general use for the purposes mentioned above. It has an actual money value that is recognized in Europe not only by the farmers, who purchase large quantities of it for use on the land, but also by the manufacturers of commercial fertilizer, who use it to good advantage as a filler or makeweight in the manufacture of their goods.

○